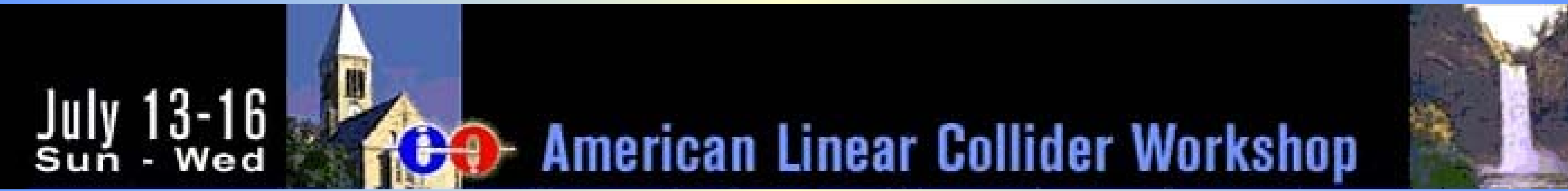


Highlights from the American Linear Collider Workshop 2003

Fulvia Pilat

CAD Seminar, July 24 2003

Outline

- Brief intro/**primer** to LC projects
- **ALCW** workshop
- **IR/beam delivery** session
- **Accelerator physics** and **simulation** session
- **BNL** based LC activity
- The **international 'roadmap'** towards LC

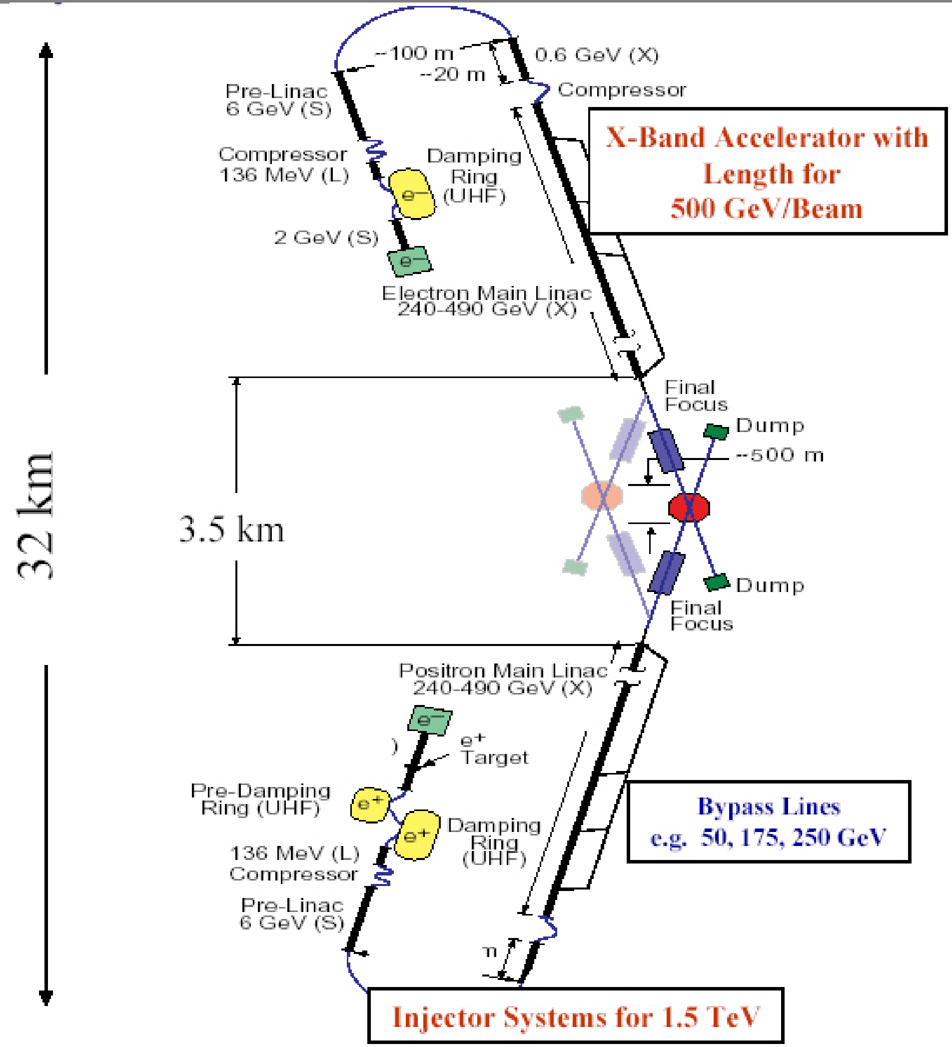
LC Primer

- A **500 GeV c.m. linear collider** with an **upgrade path to 1 TeV** has been endorsed by HEPAP as the central project for High Energy Physics in the 2002 'roadmap' document following Snowmass 2001
- 3 LC projects exist worldwide:

GLC/NLC	warm RF technology (SLAC/KEK)
TESLA	SC RF technology (DESY)
CLIC	two-beam powering scheme (CERN)

"US cold option" Tesla-NLC hybrid that morphs the Tesla DR and main linac to the NLC beam delivery system (crossing angle, compact FF optics) studies to allow the "technology choice" – warm vs. cold RF - to be on equal footing. (by ~mid 2004)

GLC/NLC (former JLC/NLC)



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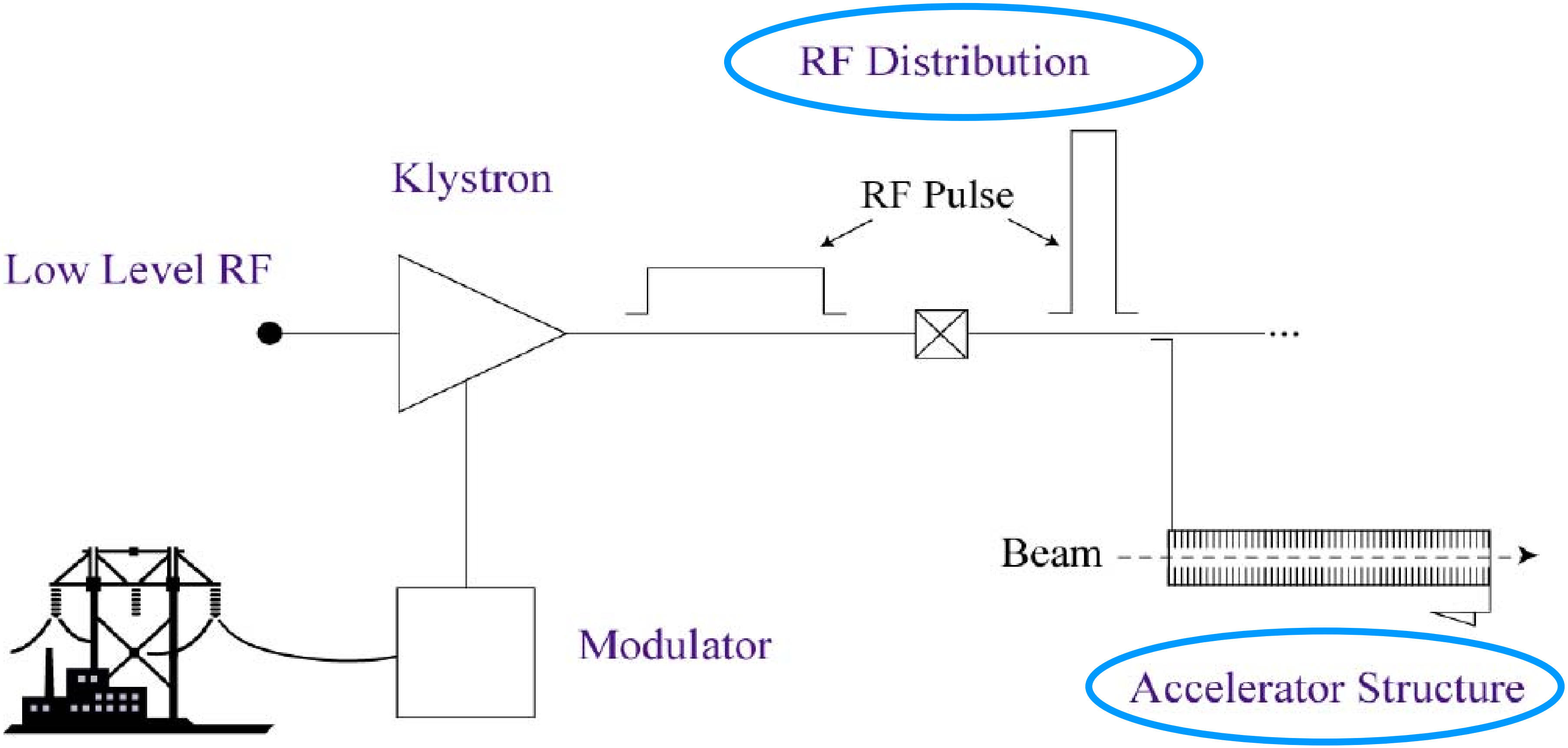
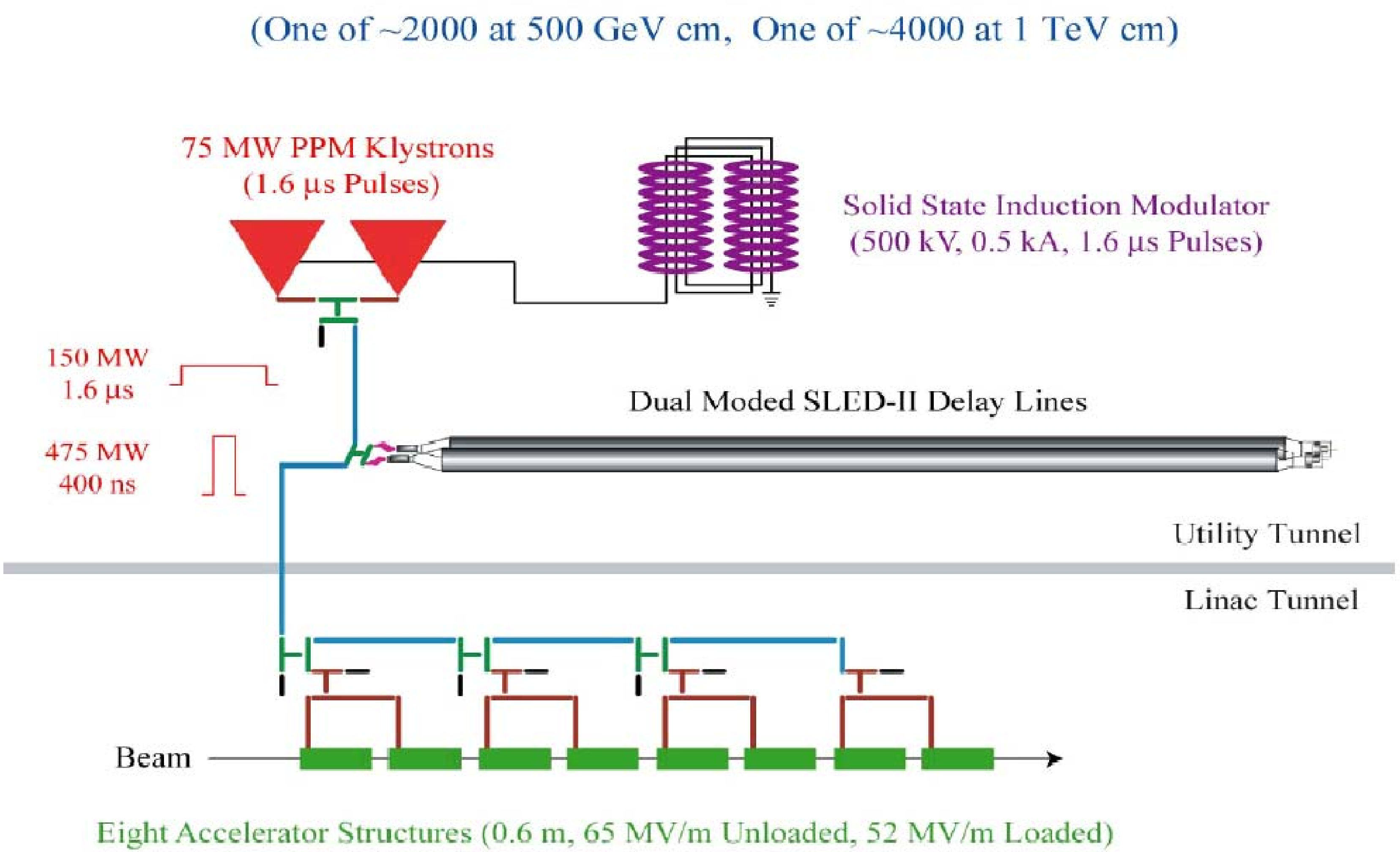
NLC RF (simplified)



NLC RF schematics



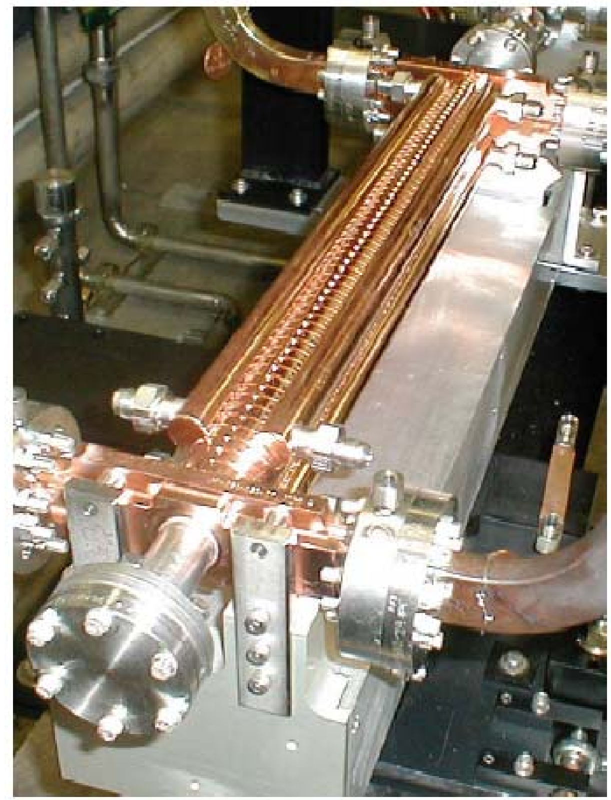
NLC RF structures - development

(65 MV/m Unloaded Gradient Goal for 0.5 & 1 TeV Collider)

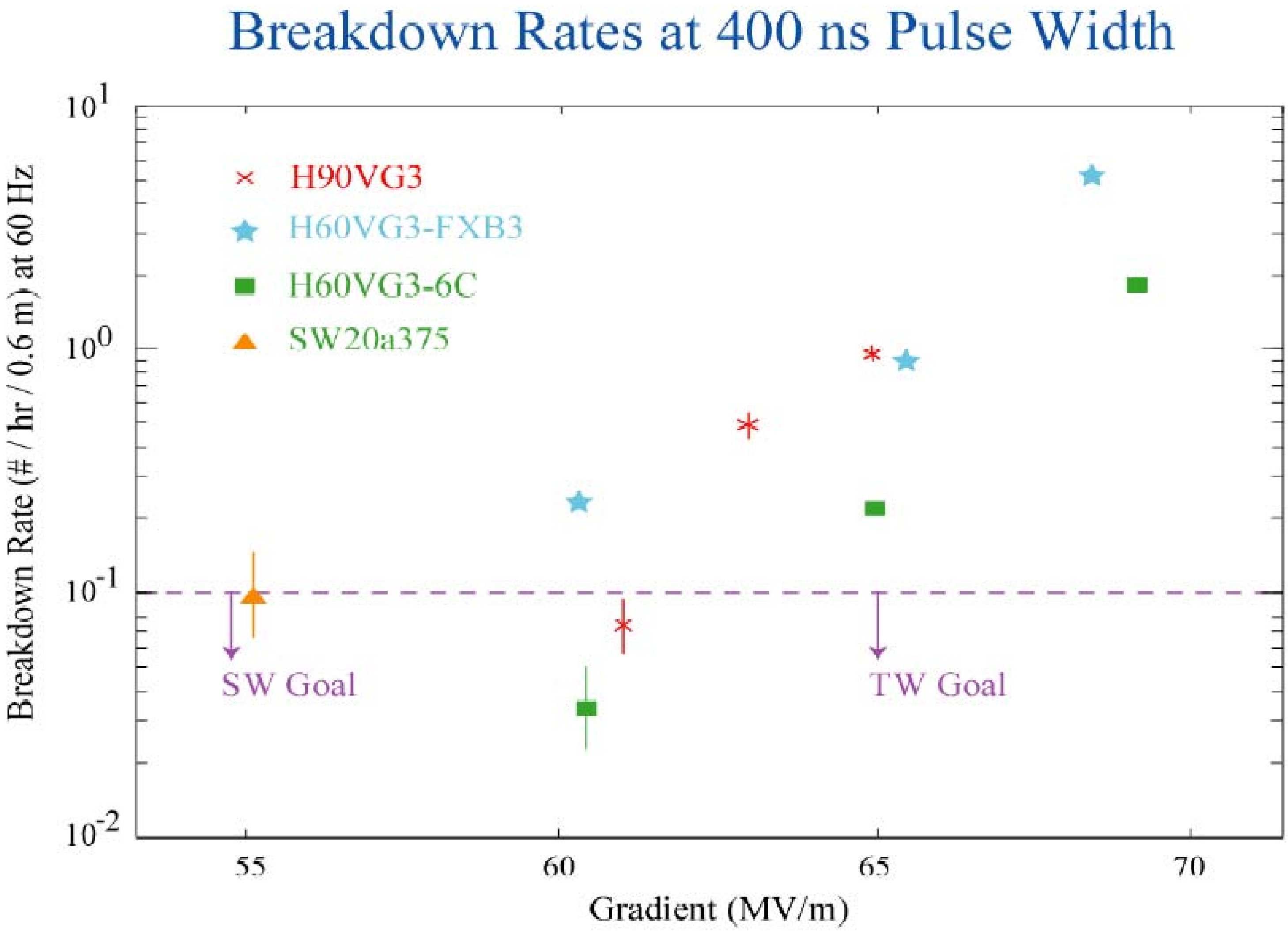
Making Steady Process Toward an 'NLC/JLC – Ready' Structure

- During Past Year Operated a Structure at 90 MV/m with an Acceptable Trip Rate (< 0.1/hr).
- Currently Developing Structures with Suitable Average Iris Radii from a Wakefield Perspective.
- Recent Structures Include Slots for Wakefield Damping.

53 cm Traveling-Wave Structure



NLC RF structures - performance



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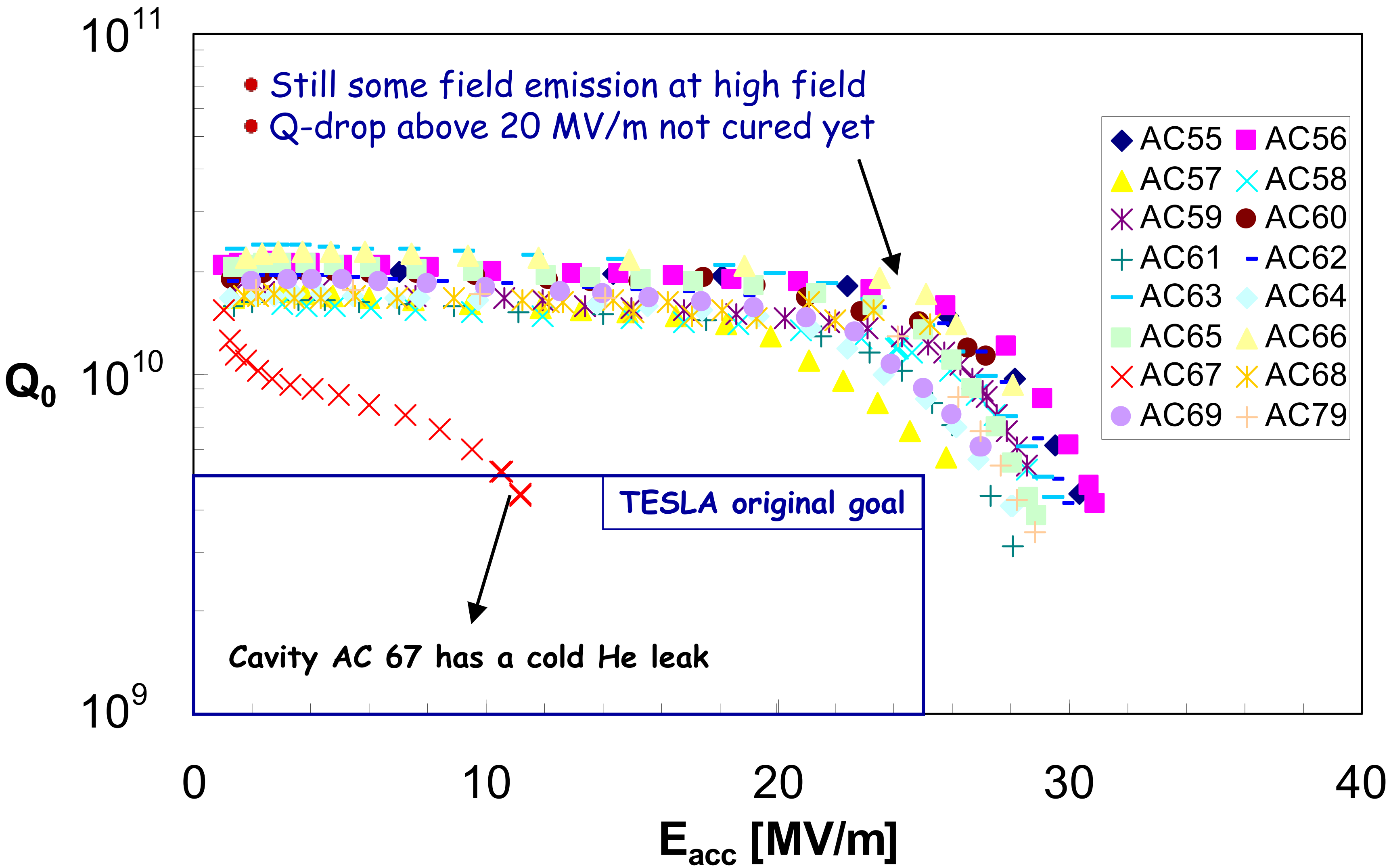
Tesla: sc cavities



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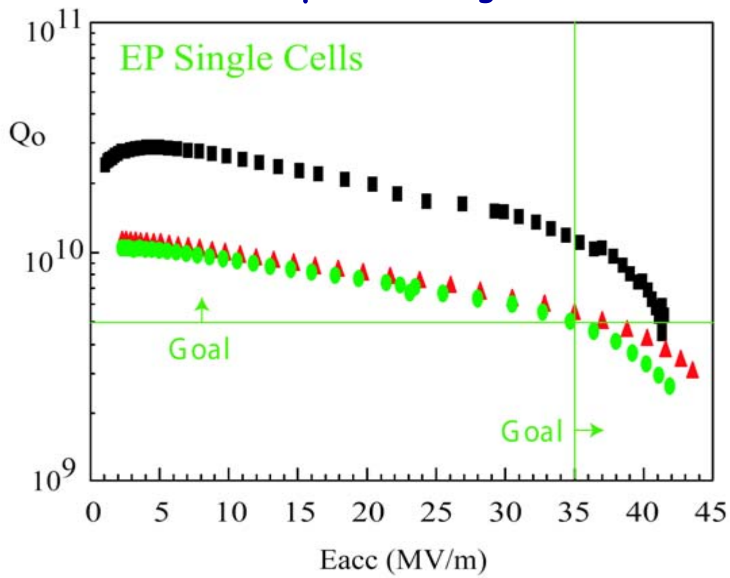
Electro-polishing for 35 MV/m

- EP developed at KEK by Kenji Saito (originally by Siemens)
- Coordinated R&D effort: DESY, KEK, CERN and Saclay

BCP Surface
($1\mu m$ roughness)

First electro-polished single cell cavities



EP Surface
($0.1\mu m$ roughness)

Electro-polishing (EP) instead of the standard chemical polishing (BCP) eliminates grain boundary steps → Field enhancement.

Gradients of **40 MV/m** at Q values above 10^{10} are now reliably achieved in single cells at KEK, DESY, CERN, Saclay and TJNAF.

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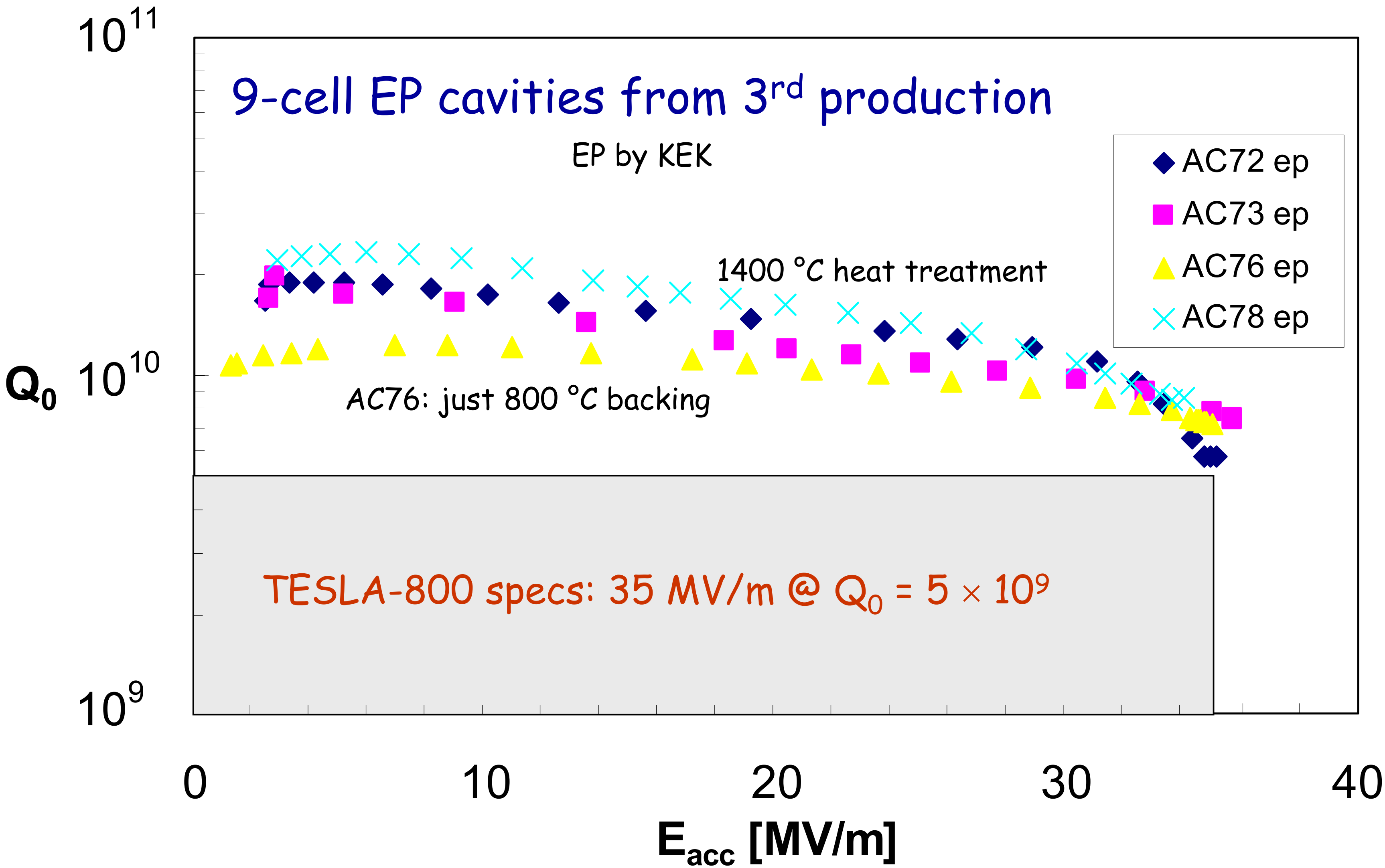
TESLA 800 Performances

Vertical Tests



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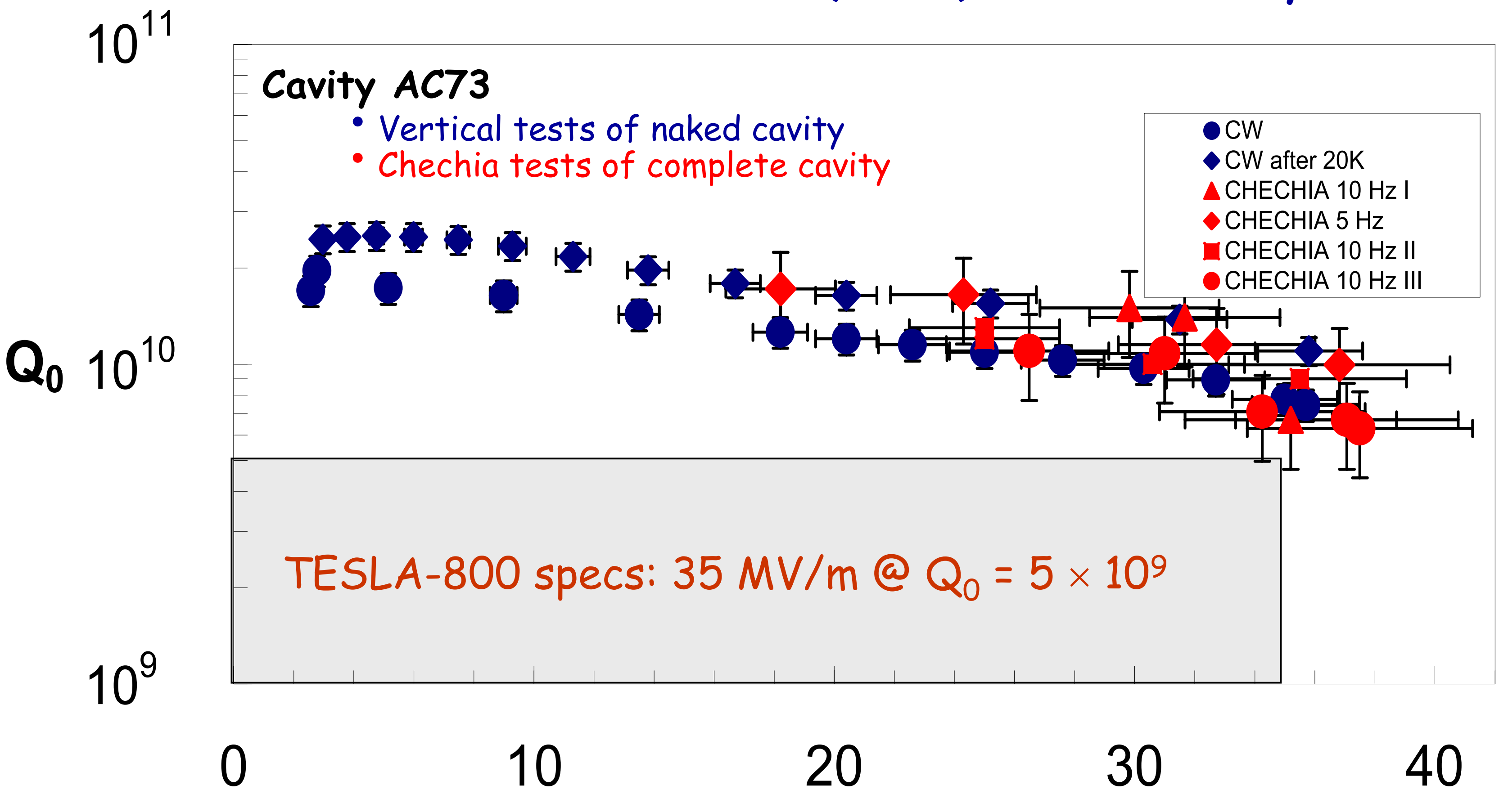
TESLA 800 in Chechia

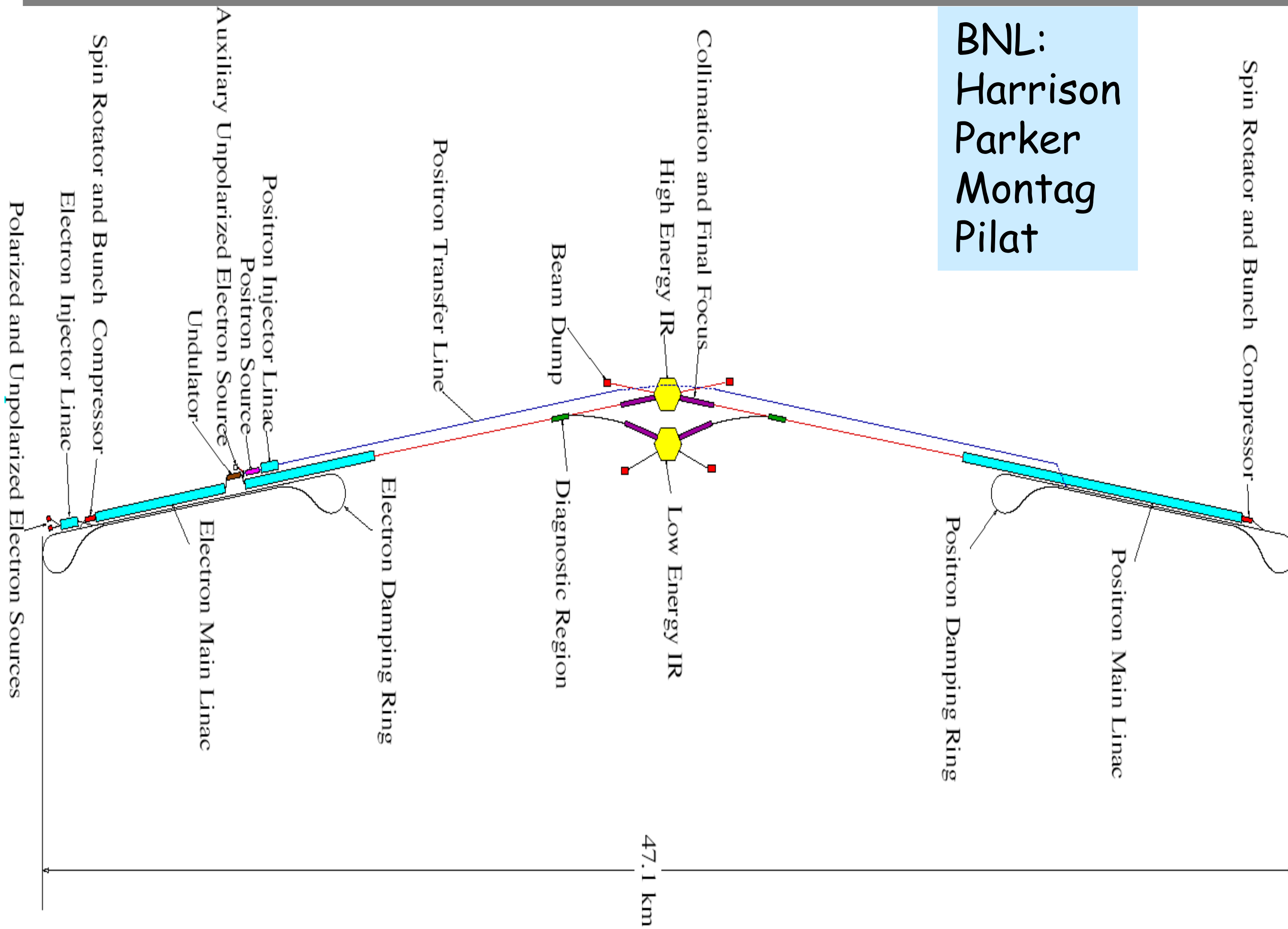
Long Term (> 600 h) Horizontal Tests

- In Chechia the cavity has all its ancillaries
- Chechia behaves as 1/8th (1/12th) of a **TESLA cryomodule**

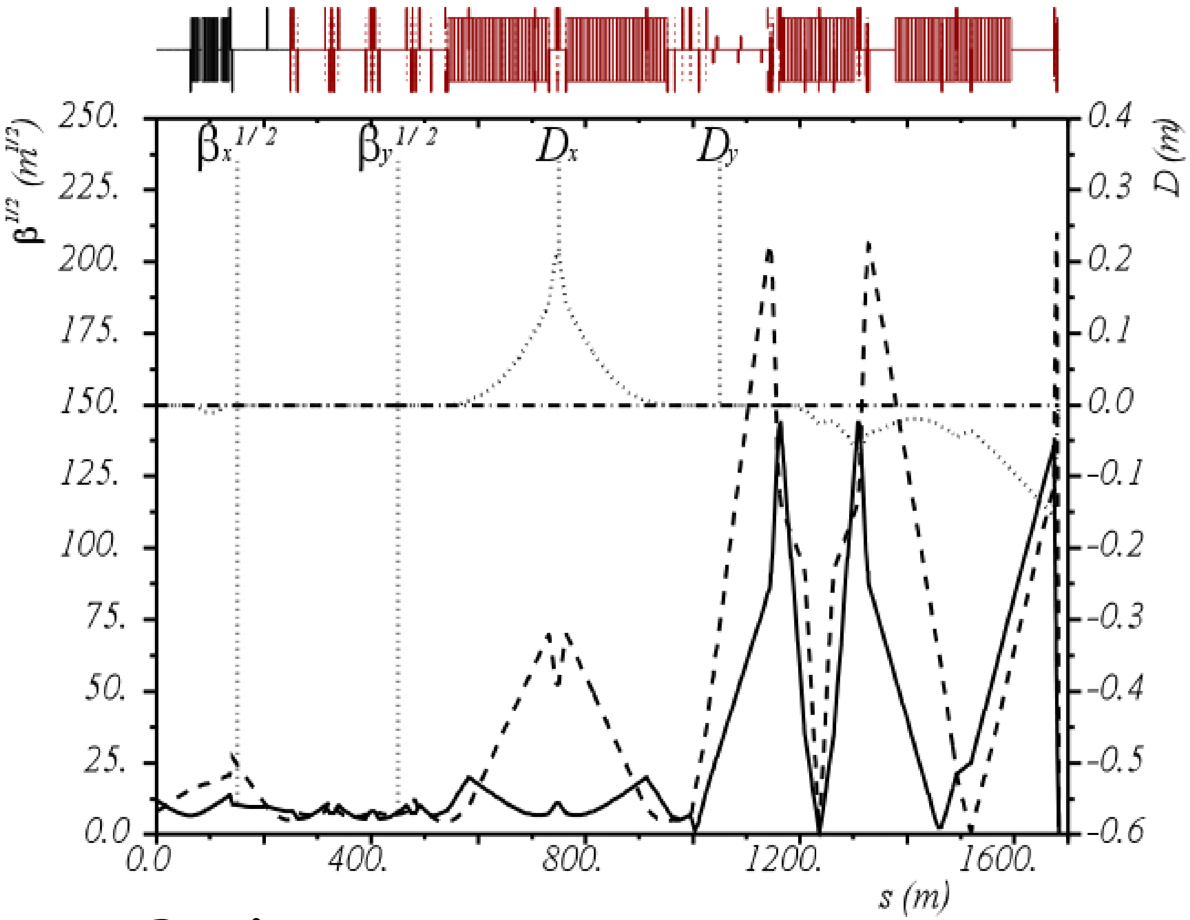


US “cold option”

BNL:
Harrison
Parker
Montag
Pilat



Beam Delivery System – optics design



Parker

A TESLA linac lattice is matched into an unmodified NLC beam delivery system via a **~200m matching section.**

The **NLC beam delivery system** is then adjusted to give TESLA lattice functions at the IP using the matching section.

β^*x,y= 15, 0.4 mm at IP

This matching section is then used for the **fast extraction** (beam abort/ tune-up line) system.

2 separate dumps per beam

Cold option reference design

The major changes made to the TESLA design are:

- An **increase in the upgrade energy** to 1 TeV (c.m.), with a tunnel of sufficient length to accommodate this in the initial baseline, assuming a 35 MV/m gradient.
- Use of the **same injector beam parameters for the 1 TeV** (c.m.) upgrade as for 500 GeV (c.m.) operation
- The choice of **28 MV/m** as the initial main linac design gradient for the 500 GeV (c.m.) machine
- The use of a **two-tunnel architecture** for the linac facilities.
- An expansion of the spares allocation in the main linac
- A re-positioning of the positron source undulator to make use of the 150 GeV electron beam, facilitating operation over a wide range of collision energies from 91 to 500 GeV
- **The adoption of an NLC-style beam delivery system with superconducting final focus quadrupoles, which accommodates both a crossing angle and collision energy variation**
- **At the subsystem and component level, specification changes to facilitate comparison with the warm LC option.**

Major ALCPG Meetings/Workshops since Fall 2002

• LCDsoft	NIU	Nov 7-9
• γ collider workshop	SLAC	Nov 21-22
• LHC/LC	Fermilab	Dec 12-13
• **ALCPG**	**UT-Arlington**	**Jan 9-11**
• LoopfestII	Brookhaven	May 14-16
• LC Sim Wkshp	SLAC	May 19-22
• **ALCPG**	**Cornell**	**Jul 13-16**

CORNELL

…and many other WG meetings
(see the WG web pages
and talk to the WG leaders)

IR/Beam Delivery WG

Accelerator Working Group: Beam Delivery & IR

Tuesday, July 15, 8:30-10:30 a.m.

8:30-8:55	Overview of IR & BDS issues	Tom Markiewicz
8:55-9:25	Collimation and Second IR for NLC	Andrei Seryi
9:25-9:45	Status and plans for linear colliders R&D in UK	Philip Burrows
9:45-10:10	The compact superconducting final focus doublet option	Brett Parker
10:10-10:30	Vibration and stabilization	Richard Partridge

Conveners: **F.Pilat,BNL T.Mattison,UBC**

"editorial" comments

IR designs are converging

- projects **adopting**, or at least **considering**, ideas from other designs:
- **optics, crossing angle, super-conducting quads, vibration, collimation**

Eternal questions remain (there are no solutions, only decisions……) → trade-offs:

- **machine luminosity - vertex detector radius**
- detector acceptance and access - machine components and supports

IR Issues (Markiewicz)

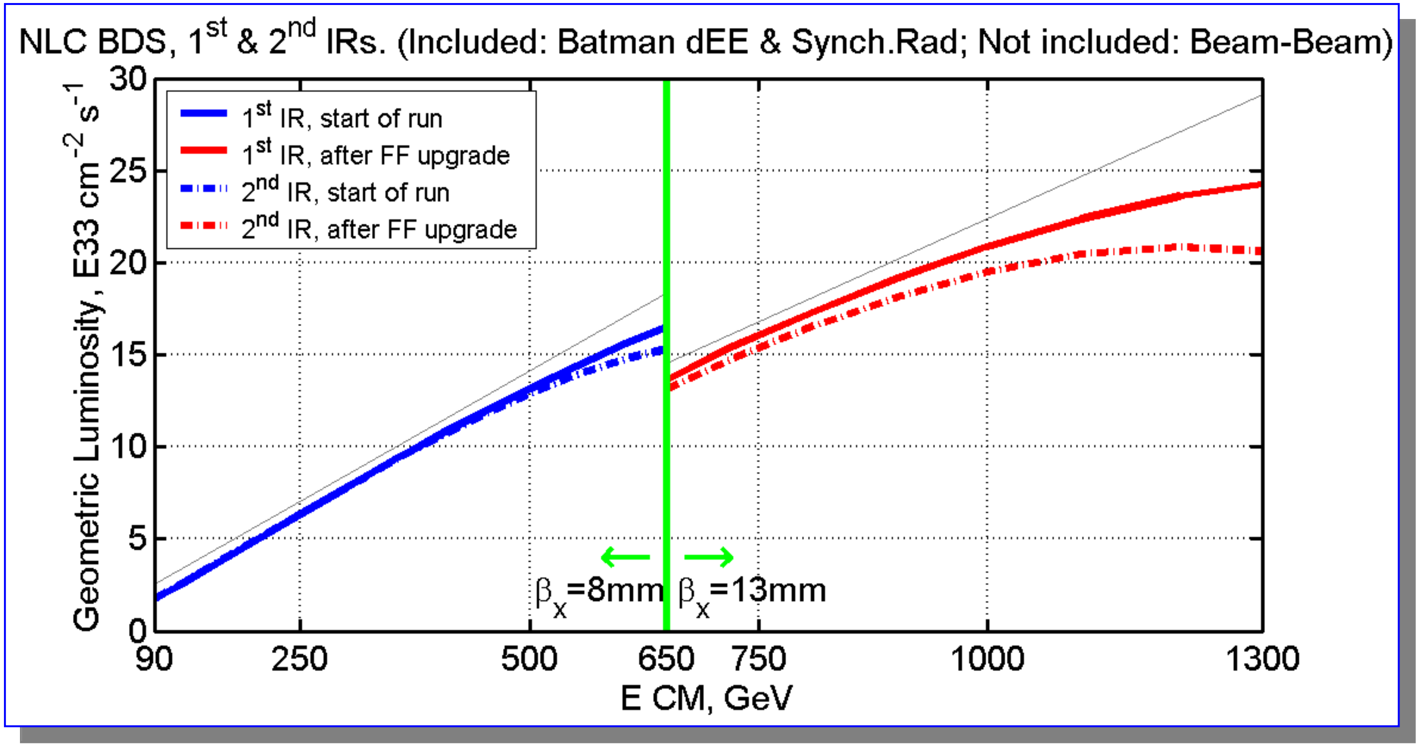
- Crossing Angle
  - Crab Cavities
  - Beam Extraction
- Physics & Detector
  - Beam Pipe Radius @ IP
  - Solenoid Field
  - Detector Access Model
  - Energy Flexibility
- **Backgrounds**
  - Detector Masking
  - Heat / Radiation
- **Final Doublet Support**
  - Support Tube
    - Cantilevered
    - Across IP
  - Vibration Control
    - Inertial Feedback
    - Optical Feedback
    - Feed-forward
  - Beam-Beam Feedback
    - Intra-train
    - 120 Hz
- Machine Diagnostics
  - Luminosity
  - Energy
  - Polarization

Second IR

Possible to achieve very comparable luminosity, over wide energy range

Design strategy: lengthen the 2nd IR BDS (several design iterations) – reduce SR $\delta\varepsilon/\varepsilon$ in the big bends

Seryi



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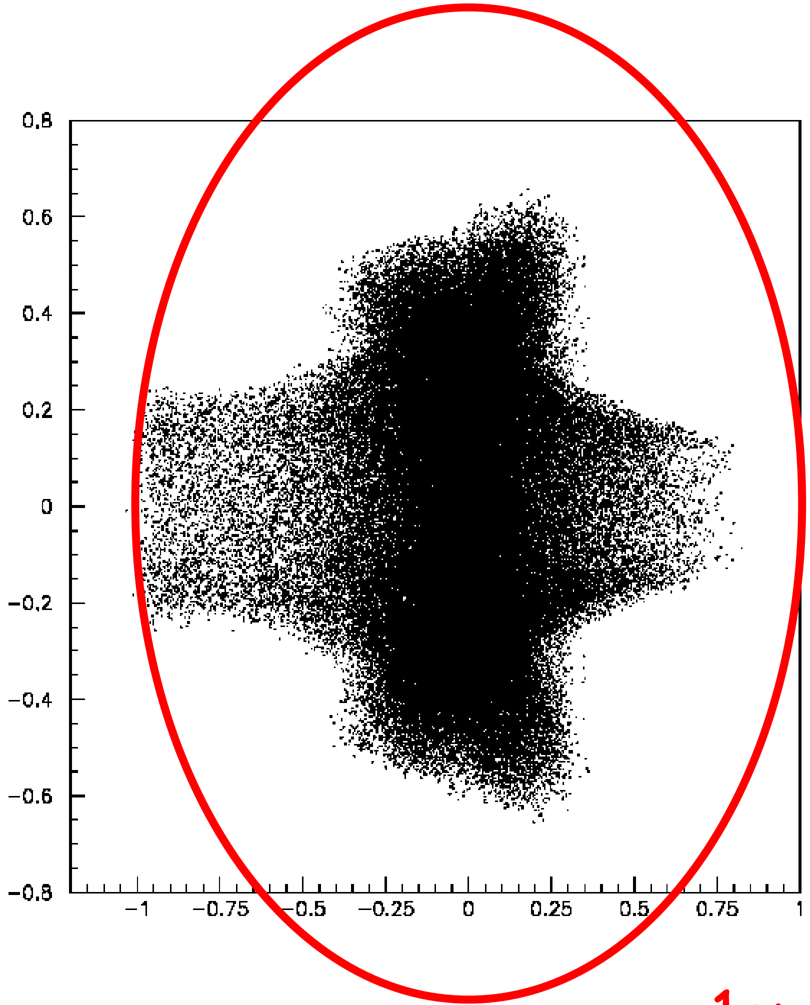
Backgrounds

control with:

- Large apertures
- beam collimators
- radiation shields
- muon spoilers

ILC-TRC: designs are an existence proof that solutions exist



Markiewicz Seryi

SR at IP from halo

X Y plot (cm)

1cm Beampipe

Vibrations/stabilization

Vibrations of final quads (Markiewicz, Partridge, Burrows)

- **Feedback using beam-beam deflection + steering**
  everyone uses it for **slow drifts** (many seconds)
  TESLA can do it **bunch by bunch**
  tests of **nanosecond bunch feedback at NLCTA**
- **Stabilization: quad position measurement and control feedback**
  SLAC: 6-axis feedback of block on springs with accels + electrostatic
  quad and support mockup feedback project
  specialized accelerometer R&D
- **Rigid support tube across IP**
  KEK comparing finite-element calcs to simple cantilever & span geometries
  building 1/10 scale support tube prototype

Quad&support mockup FBK

Partridge

Compact SC FF doublet

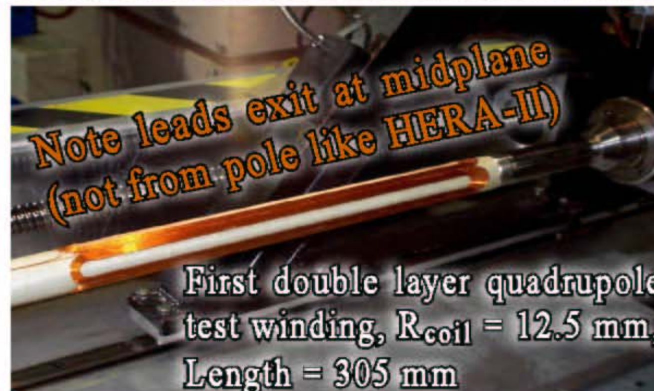
Parker

Planned: warm field quality measurements, cold quench tests

BNL LDRD Accomplishments & Areas of Ongoing Development

BROOKHAVEN NATIONAL LABORATORY
Superconducting Magnet Division
NLC - The Next Linear Collider Project

First made small diameter single-layer (HERA-II) coils with desired features. Then went on to short double-layer windings.



Next wound 1m coils (see above) & found stylus pressure bows tube. Now making 2m coils with mid-point support (right).

Superconducting Final focus- BNL design

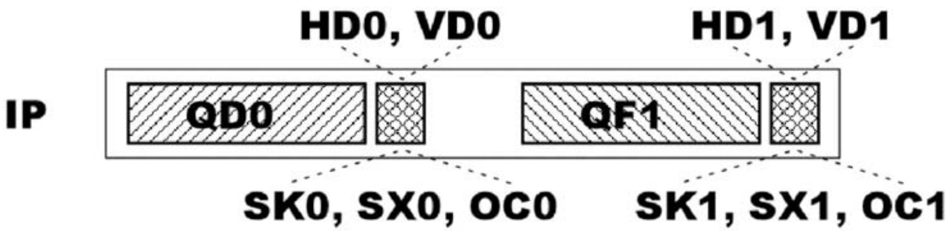


Figure 6.3: Superconducting Final Focus Magnet Layout Schematic

Linear+nonlinear FF corrector layers (operational experience at RHIC positive for skew quad, sextupole and octupole correction)

144 T/m @ 250 GeV
Aperture 20 mm

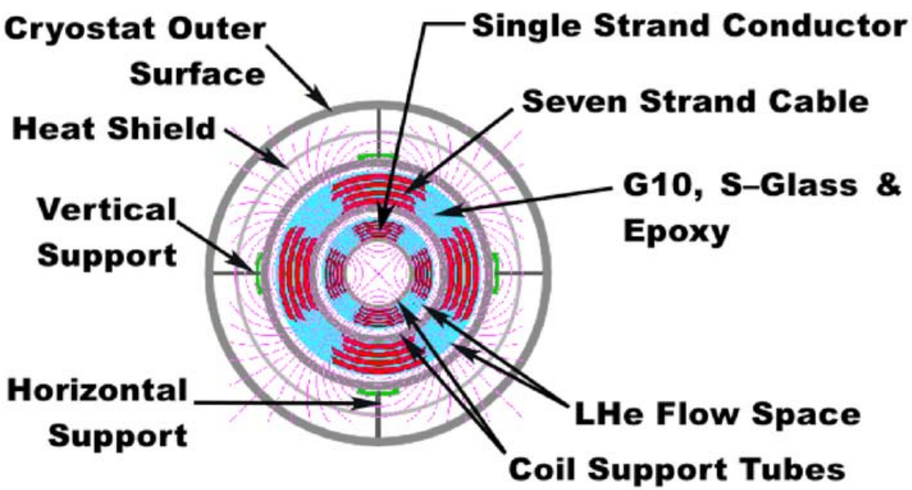


Figure 6.4: Superconducting QD0 Design Schematic

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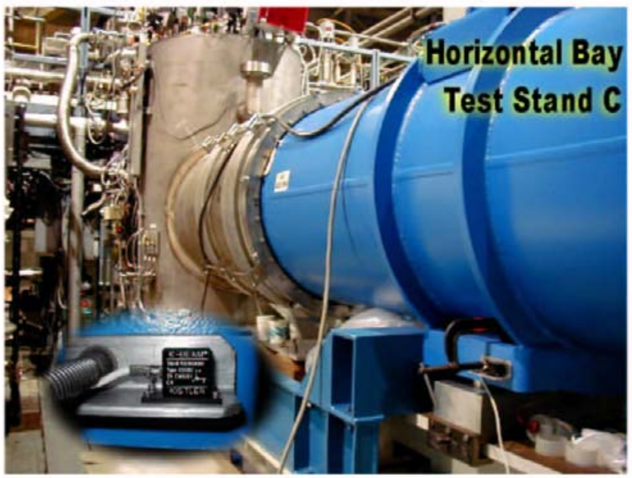
SC FF doublet stabilization

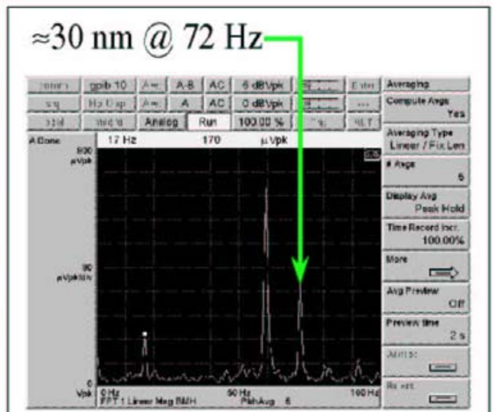
Parker

From RHIC BPM data (triplet cryo vibration):
~200 nm (horizontal)
~0 nm   (vertical)

First Superconducting Magnet Vibrations Studies at BNL Magcool

BROOKHAVEN NATIONAL LABORATORY
Superconducting Magnet Division
NLC - The Next Linear Collider Project





Frequency Spectrum

- Some equipment is now available (see photos).
- Thinking about how to do cold measurements.
- But still just getting started.

- Plans for measurements on cryostats and then cold masses

- Vigorous R&D on vibration and stabilization of SC magnets necessary, needs:

RESOURCES ($)
COLLABORATION

LC Program in UK (Burrows)

Accelerator Science & Technology Centre established in 2000

$4M seed money for **FY00-03** from PPARC + UK labs for ASTeC + universities

8 accel-related projects, 18 FTEs incl 6 students in collab with offshore labs

no time to summarize them

$14M for **FY04-05**, perhaps $17M for FY04-06, for accelerator science, **"bulk" for LC**

PPARC LC steering group: focus on **beam delivery and machine-detector interface**

Goal is to ramp up to ~10% UK contribution to LC project

(Phil says the Queen has still to sign on that though….☺)

Simulation/Dynamics WG

Accelerator Working Group: Beam Dynamics and Accelerator Simulation I

Sunday, July 13, 1:00-3:00 p.m.

1:00-1:20	UCLC Progress Report: Accelerator Physics Research at NIU, July, 2002 - July, 2003	Court Bohn
1:20-1:40	UCLC Progress Report: Beam Simulation (ppt pdf)	David Rubin
1:40-2:20	Reliability and Operations Modeling of a Linear Collider (ppt pdf)	Tom Himel
2:20-3:00	Emittance Tuning: Details, Details,... (ppt pdf)	Peter Tenenbaum

Accelerator Working Group: Beam Dynamics and Accelerator Simulation II

Tuesday, July 15, 10:55 a.m. -12:55 p.m.

10:55-11:15	LCRD Progress Report: Low-Emittance Electron Beams for Wakefield Measurements (ppt pdf)	John Power
11:15-11:35	UCLC Progress Report: Update on the Usability of Spent Beams for Physics Experiments at the Linear Collider	Sekazi Mtingwa
11:35-12:15	Simulation of Damping Ring Issues	Andy Wolski
12:15-12:55	Simulation Techniques	Andrei Seryi

Conveners: Raubenheimer, Poling

LC simulations/dynamics

- **Object**

Performance → peak luminosity (**PT**, **Seryi**)

Reliability → integrated luminosity (**Himel**)

- **Level of detail**

More **physics** (**Wolski**: wiggler in DR, **Bohn**: space charge)

Integration (**Seryi**: DR-to-IP, 2 beams, GM BB FBK..→luminosity)

- **Validation**

'building blocks' (**Seryi**→ collimator wake measurements vs.model)

X-checks, **benchmarking** of different codes (**Seryi**, ILC-TRC)

- **Widening LC dynamics/simulation community**

LC simulation environment setup (**Rubin** – Cornell, UK, BNL….)

Simulation results **database** (Burrows)

Reliability simulation (Himel)

Preliminary results: cold machine

% time down	# access per month	# tun-nels	energy over-head	MTBF fudge	special conditions
25.3	2.9	2	2%	1	Double tunnel
45.4	14.1	1	2%	1	
39.6	12.1	1	4%	1	
36.9	10.1	1	2%	10	Increase MTBF
26.8	6.4	1	4%	10	
27.0	6.1	1	4%	10	different seed
13.6	3.4	2	2%	1	Decrease tuning time
24.7	2.9	2	2%	1	
19.8	3.3	2	2%	1	
15.6	2.3	2	4%	10	

- Write a simulation that given the **MTBFs**, **MTTRs**, components **access requirements** for repair can calculate **availability** & **integrated luminosity**
- Collect component data in existing machines for guidance
- **Iterate** as many times as we have time to **minimize the overall cost** of the LC while maintaining the goal availability

Different methodology (Tesla):

FMEA (Failure Mode Effect Analysis)

→ identify **critical components**

- Interesting for existing machines
- Potential for assessing machine availability during commissioning phase

The devil is in the details (PT)

- Emittance growth from DFS - Tesla
- Effect of jitter in NLC DFS
- Emittance growth in NLC bypass line…..

❑ **necessary to include details**:

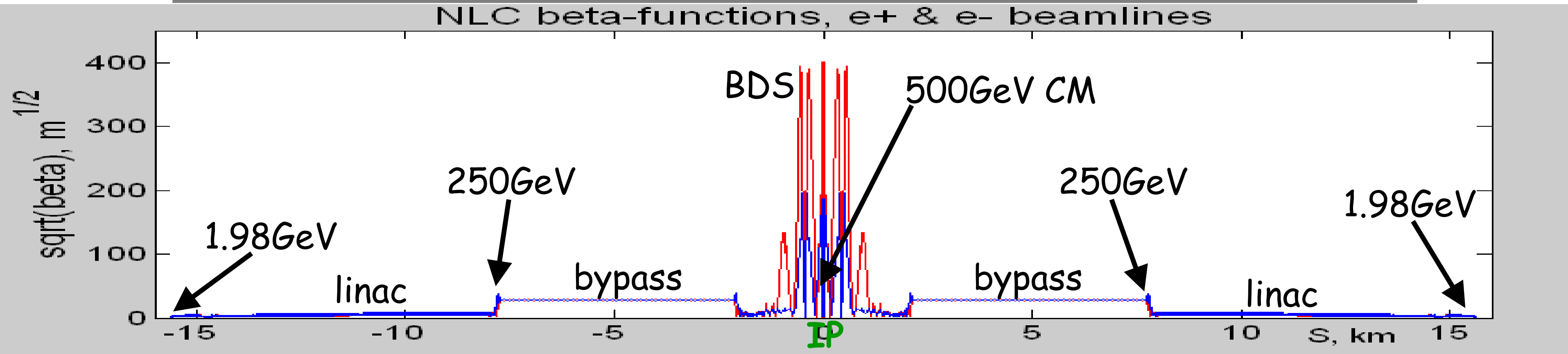
jitters, drifts, RF trips and deflections and especially interaction with **feedback loops**

❑ Tuning simulation on **signals that will be available in control room**

→ Will be necessary to carefully develop a **commissioning strategy**

DR => IP <= DR integrated simulation tools

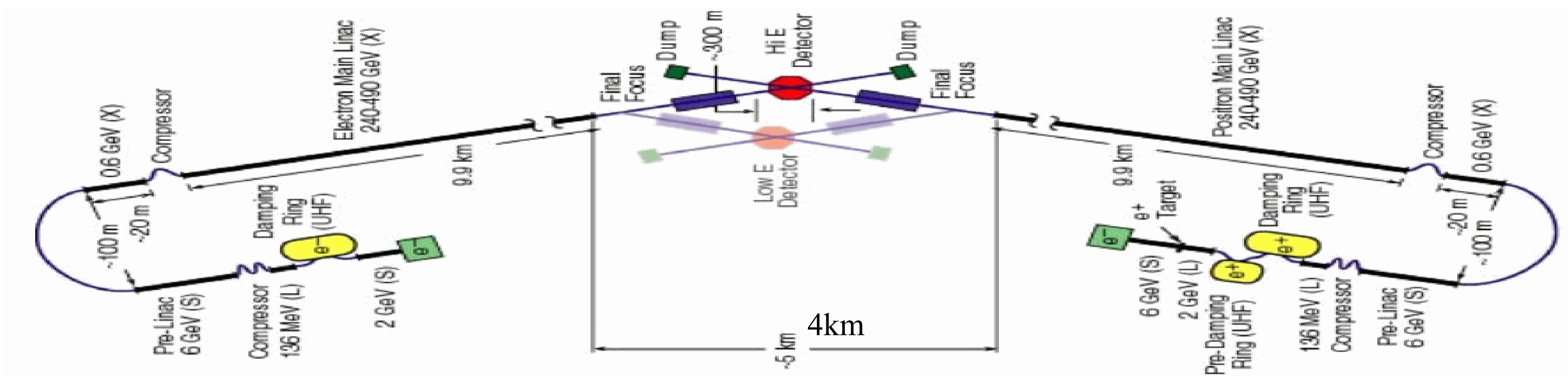
ILC-TRC



DIMAD – in Bunch Compressor and Beam Delivery System (high order optics, accurate particle tracking)
LIAR – in Linac (wakes, fast tracking of macroparticles)

} MATLAB driven

GUINEAPIG – beam-beam collisions at IP
PLACET or MERLIN – in either BC, Linac or BDS



Virtual NLC ?

1 bunch, 500 pulses takes 10 hours on 2GHz PC

(and this is with quite limited physics included)

Real time calculations (120Hz, 192 bunch/train) will require:

300000 of 11.4GHz ideally parallel processors

If each of them is 1cm long, they will span over 3km

Easier to build real NLC

The bodies

LCRD

UCLC

ALCPG

USLCSG

DOE

NSF

WorldWideStudy

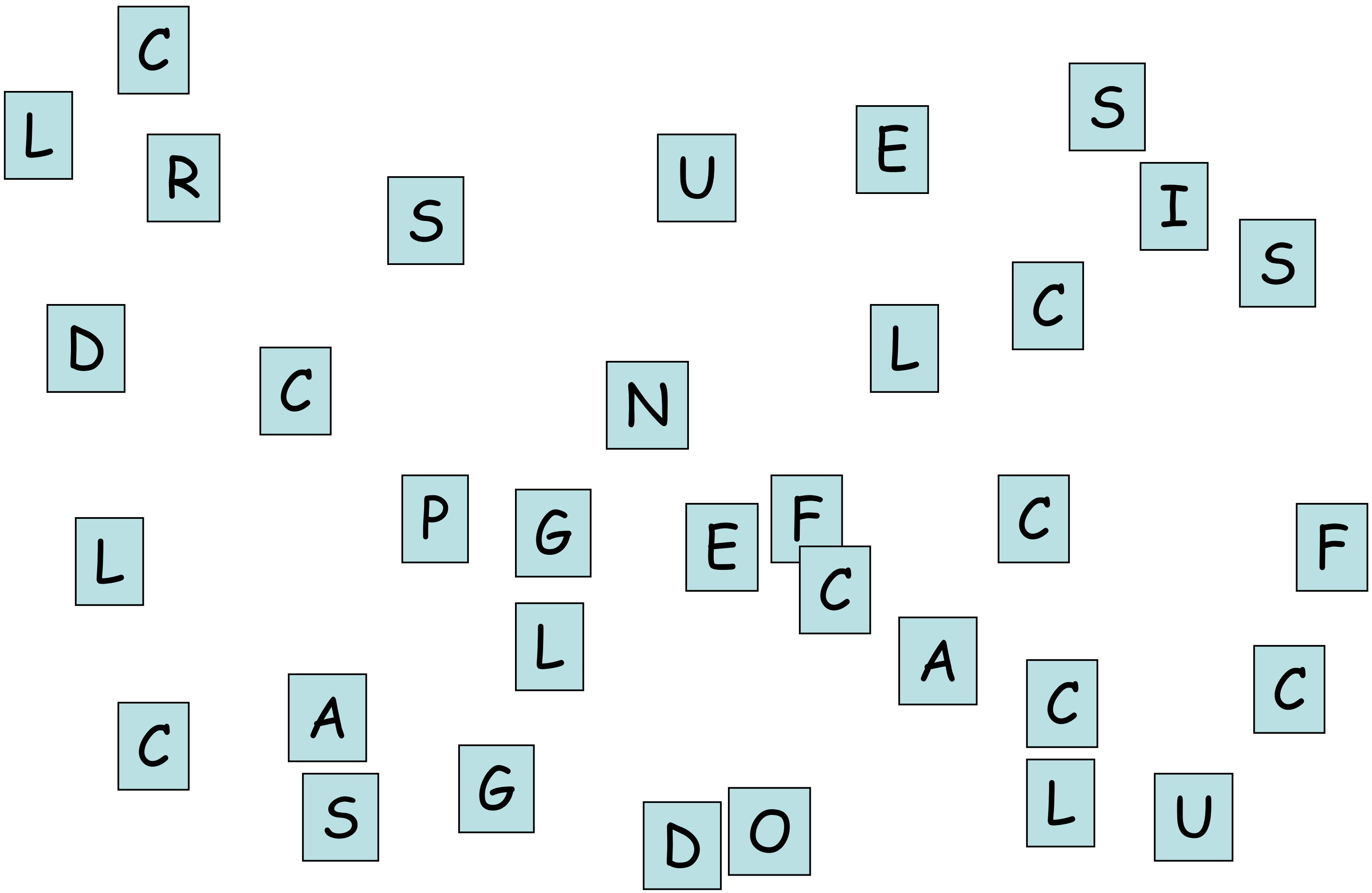
ILCSC

ICFA

ACFA

ECFA

Does this remind you of Scrabble?



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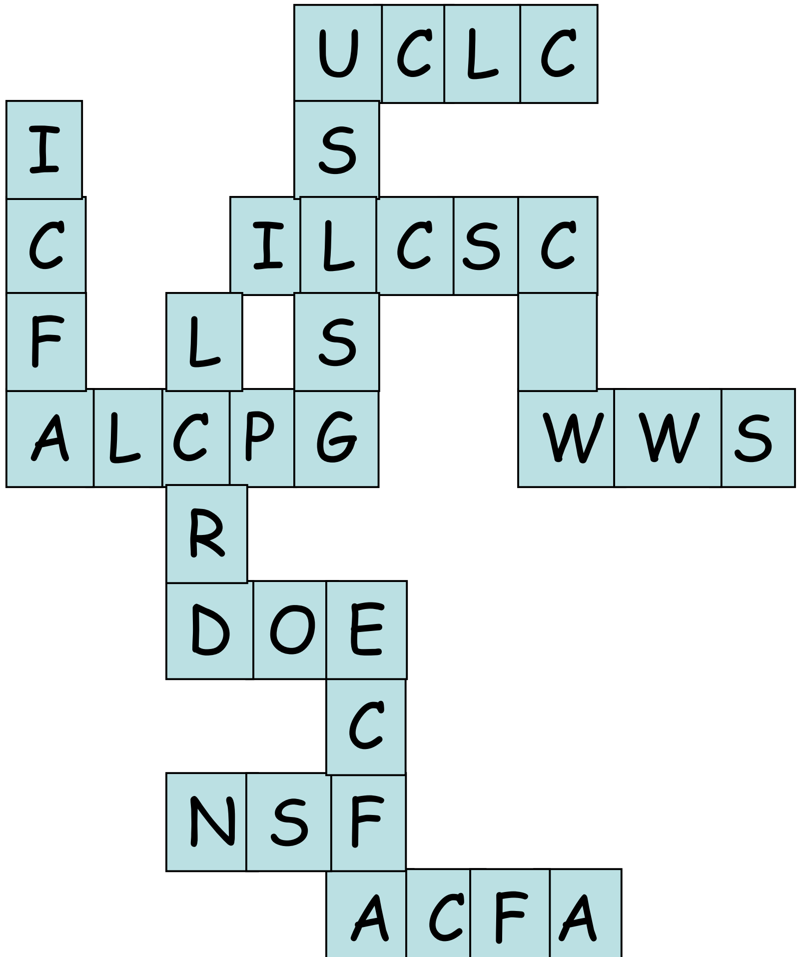
Scrabble and the Linear Collider



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US Regional Structure

US Linear Collider Steering Group
(J. Dorfan)

Physics and Detectors Subcommittee

American Linear Collider
Physics Group
http:blueox.uoregon.edu/~lc/alcpg

Working Group Leaders

Co-chairs: Jim Brau and Mark Oreglia

Detector and Physics Simulations:
N. Graf/M. Peskin
Vertex Detector:
J. Brau /N. Roe/M Battaglia
Tracking:
B. Schumm/D. Karlen/K. Riles
Particle I.D.:
B. Wilson
Calorimetry:
R. Frey/A. Turcot/D. Chakraborty
Muon Detector:
G. Fisk
DAcq, Magnet, and Infrastructure:
U. Mallik
Interaction Regions, Backgrounds:
T. Markiewicz/S. Hertzbach
IP Beam Instrumentation:
M. Woods /E. Torrence/D. Cinabro

LHC/LC Study Group
- chaired by H. Schellman/F. Paige

Executive Committee
E. Blucher
D. Gerdes
L. Gibbons
D. Karlen
Y-K Kim
H. Murayama
J. Richman
R. VanKooten

Higgs:
R. Van Kooten/M. Carena/H. Haber
SUSY:
U. Nauenberg/J. Feng /F. Paige
New Physics at the TeV Scale and Beyond:
J. Hewett/D. Strom/S. Tkaczyk
Radiative Corrections (Loopverein):
U. Baur/S. Dawson/D. Wackeroth
Top Physics, QCD, and Two Photon:
Lynne Orr/Aurelio Juste
Precision E
Graha
gamma-gar
Jeff
e-e-:
Clem

Liaison to accel. R&D
T. Himel, D. Finley, J. R

Global Detector Network
M. Hildreth/R. Van Kooten

Testbeams
G. Fisk, J. Yu

UCLC and LCRD
D. Amidei, G. Dugan,
G. Gollin, J. Jaros,
U. Mallik, R. Patterson,
J. Rogers, S. Tkaczyk

Accelerator Subcommittee
chair: G. Dugan

International Subcommittee
chair: M. Tigner

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OFFICE OF SCIENCE
U.S. DEPARTMENT of ENERGY

NSF

Canadian support as well

Linear Collider.ca

World-wide Structure

International Linear Collider Steering Committee
(established 2002) (M. Tigner)

Physics and Detectors Subcommittee

<u>Organizing Committee of the World-wide Study of Physics and Detectors for Future Linear e+e- Colliders</u> (est. 1998, ICFA)

J. Brau, D. Miller, H. Yamamoto, co-chairs

(past co-chairs C. Baltay, S. Komamiya)

- Coordinates three regional studies
- Organizes LCWS (Paris, April 19-23,2004)
- Fills subcommittee role to ILCSC

Accelerator Subcommittee

Greg Loew, chair

Parameters Subcommittee

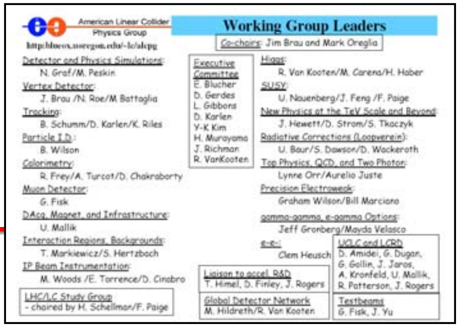
Rolf Heuer, chair

Communications Subcommittee

N. Calder et al

ACFA Joint Linear Collider
Physics and Detector Working Group

American Linear Collider
Physics Group



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Physics Group
http://blueox.uoregon.edu/~lc/alcpg

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Lynne Orr/Aurelio Juste
<u>Precision Electroweak</u>:
Graham Wilson/Bill Marciano
<u>gamma-gamma, e-gamma Options</u>:
Jeff Gronberg/Mayda Velasco
<u>e-e-</u>:
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<u>Testbeams</u>
G. Fisk, J. Yu

ECFA Study

http://blueox.uoregon.edu/~lc/wwstudy

The international 'roadmap' to LC

- Snowmass (**2001**) and HEPAP endorsement
- ILCSC/accelerator subcommittee (Loew) issued a **comprehensive report** overviewing and comparing the designs of NLC/JLC, Tesla, CLIC (**2002**)
- Development of a **"cold option"** for fair comparison to the "warm option" (**2003**)
- **Technology choice** – ILCSC (Tigner) – **mid 2004** (committee of 'wise-persons')
- Establish an **international design group** (**2004-2005**)
- Produce a **CDR** (**2005**)
- Produce a **TDR** (**2007**)
- **Approval** & begin construction (target **2009**)
- **Commissioning** (target **2014**)

Fulvia Pilat, American Linear Collider Workshop 2003

Conclusions (from Jim Brau)

American Linear Collider
Physics Group

- We are making good progress on many fronts
- We are getting support for university R&D, making possible a real start on the detector and machine R&D
- **We have a long way to go**
- **Keep up the charge**